

FCC MAIL SECTION
Federal Communications Commission

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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of)	
)	
Amendment of the Commission's Rules to)	ET Docket No. 96-102
Provide for Operation of Unlicensed NII)	RM-8648
Devices in the 5 GHz Frequency Range)	RM-8653

REPORT AND ORDER

Adopted: January 9, 1997

Released: January 9, 1997

By the Commission: Commissioner Ness issuing a statement.

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INTRODUCTION

1. By this action, we amend Part 15 of our rules to make available 300 megahertz of spectrum at 5.15-5.35 GHz and 5.725-5.825 GHz for use by a new category of unlicensed equipment, called Unlicensed National Information Infrastructure ("U-NII") devices.¹ These devices will provide short-range, high speed wireless digital communications on an unlicensed basis. We anticipate that U-NII devices will support the creation of new wireless local area networks ("LANs") and will facilitate wireless access to the National Information Infrastructure ("NII").² In order to permit significant flexibility in the design and operation of these devices, we are adopting the minimum technical rules necessary to prevent interference to other services and to ensure that the spectrum is used efficiently. We believe that the rules set forth herein will foster the development of a broad range of new devices and service offerings that will stimulate economic development and the growth of new industries. We also expect that this action will promote the ability of U.S. manufacturers, including small businesses, to compete globally by enabling them to develop unlicensed digital communications products for the world market.³

BACKGROUND

2. On May 15, 1995, the Wireless Information Networks Forum ("WINForum") filed a Petition for Rule Making (RM-8648) requesting that we allocate 250 megahertz of spectrum at 5.10-5.35 GHz for the operation of new high speed Shared Unlicensed Personal Radio Network ("SUPERNet") devices. On May 24, 1995, Apple Computer, Inc. ("Apple") filed a Petition for Rule Making (RM-8653) requesting that we allocate 300 megahertz in the 5.15-5.3 GHz and 5.725-5.875 GHz bands to establish a new unlicensed wireless radio service to promote the full deployment of the NII. In response to these two proposals, the Commission adopted a *Notice of Proposed Rule Making ("NPRM")* proposing to make available 350 megahertz of spectrum at 5.15-5.35 GHz and 5.725-5.875 GHz for U-NII

¹ We note that in the Notice of Proposed Rule Making in this proceeding, we referred to these devices as "NII/SUPERNet" devices. However, on July 2, 1996, we received a letter from Smart & Thevenet, P.C. on behalf of its client, SuperNet, Inc., which requests that the Commission refrain from using the word "SUPERNet" because it would infringe upon its trademark registration of the name "Colorado Supernet." Accordingly, we have adopted the term "Unlicensed National Information Infrastructure" or "U-NII" to refer to the devices in this proceeding. See Letter from Harlan S. Abrahams of Smart & Thevenet, P.C., received on July 2, 1996.

² The National Information Infrastructure or NII is a group of networks, including the public switched telecommunications network, radio and television networks, private communications networks, and other networks not yet built, which together will serve the communications and information processing needs of the people of the United States in the future.

³ For instance, as discussed below, the rules adopted herein allow for the development of devices compatible with the European High Performance LAN ("HIPERLAN") standard. See *infra*, note 44.

devices.⁴ The *NPRM* also proposed that such devices be subject to certain minimum technical standards, including power limits, emission limits, and a spectrum etiquette, to ensure that the spectrum is used efficiently, and to ensure that all U-NII devices have equal access to the spectrum. The *NPRM* solicited comments on whether we should adopt a channeling plan, whether we should adopt a minimum modulation efficiency, and whether we should regulate some U-NII operations, particularly those intended for long-range community network applications, as a licensed service. Further, the *NPRM* proposed to establish "safe-harbor rules" that would set forth conditions under which unlicensed devices could operate without risk of being considered sources of harmful interference.

3. In response to the *NPRM*, 52 comments and 26 reply comments were filed. Most commenters support making available 5 GHz spectrum for unlicensed broadband operations. However, several incumbent and potential users of this spectrum express concern about the feasibility of spectrum sharing between these new unlicensed devices and incumbent and proposed primary services.

4. The frequency bands addressed in this proceeding currently are used primarily by Federal Government operations, particularly military radar operations. Other uses of the bands are as follows: the 5.00-5.25 GHz band is allocated on a primary basis to the aeronautical radionavigation, aeronautical mobile-satellite (R), fixed-satellite, and inter-satellite services for both Government and non-Government operations;⁵ the 5.25-5.35 GHz band is allocated to the non-Government radiolocation service on a secondary basis;⁶ the 5.650-5.925 GHz band is allocated on a secondary basis to the amateur service;⁷ the 5.725-5.875 GHz band is designated for industrial, scientific and medical ("ISM") applications and unlicensed Part 15 devices,⁸ and radiocommunication services operating within this band must accept harmful interference that may be caused by ISM applications;⁹ and the 5.850-5.925 GHz band

⁴ See *Notice of Proposed Rule Making*, ET Docket No. 96-102, 11 FCC Rcd 7205 (1996).

⁵ See 47 CFR § 2.106, Table and notes 733 and 797. In addition, the 5.150-5.216 GHz sub-band is allocated on a primary basis to radiodetermination-satellite (space-to-Earth) service and to the fixed-satellite (space-to-Earth) service for feeder links used in conjunction with the radiodetermination-satellite service for both Government and non-Government operations. See 47 CFR § 2.106, notes 797A, US307.

⁶ See 47 CFR § 2.106, Table. Additionally, in the 5.25-5.35 GHz band, radiolocation stations installed on spacecraft may also be employed for the earth exploration-satellite and space research services on a secondary basis for both Government and non-Government operations. See 47 CFR § 2.106, note 713.

⁷ See 47 CFR § 2.106, Table. Additionally, the 5.65-5.67 GHz and 5.83-5.85 GHz sub-bands are allocated to the amateur-satellite service on a secondary basis. See 47 CFR § 2.106, notes 664 and 808.

⁸ On January 30, 1996, the Commission adopted a Notice of Proposed Rule Making in ET Docket No. 96-8, 11 FCC Rcd 3068 (1996), which proposed to amend the rules regarding the operation of spread spectrum transmission systems in the 902-928 MHz, 2.400-2.4835 GHz, and 5.725-5.850 GHz bands.

⁹ See 47 CFR § 2.106, note 806.

is allocated on a primary basis to the fixed-satellite (Earth-to-space) service for non-Government operations and to the radiolocation service for Government operations.¹⁰

5. On November 2, 1995, the National Telecommunications and Information Administration ("NTIA"), which manages spectrum used by Federal Government operations and is the principal Executive Branch advisor on telecommunications policy, submitted a letter addressing the WINForum and Apple petitions.¹¹ In its letter, NTIA stated that the Administration strongly supports spectrum policies that will promote affordable, high-bandwidth wireless computer networks and that the proposed WINForum and Apple devices could provide an important means of unlicensed access to the NII. To protect public safety operations, however, NTIA indicated that making available the 5.0-5.15 GHz band for unlicensed device operations is not feasible because this band must remain fully available for air traffic control operations.

6. Finally, the 1995 World Radiocommunication Conference ("WRC-95") modified some of the international spectrum allocations in the 5 GHz frequency range.¹² Of principal interest to this proceeding, WRC-95 allocated the 5.091 - 5.25 GHz band on a primary basis to the fixed-satellite (Earth-to-space) service ("FSS uplinks") to provide feeder links for non-geostationary satellite systems in the mobile-satellite service ("MSS") on a co-primary basis with Government aeronautical radionavigation.

DISCUSSION

A. *Need for U-NII Devices and Spectrum*

7. In the *NPRM*, the Commission recognized that recent developments in a number of different digital technologies have greatly increased the need to transfer large amounts of data from one network or system to another. For example, technological developments now permit digitization and compression of large amounts of voice, video, imaging, and data information, which can be rapidly transmitted from computers and other digital equipment to other devices within a network. The *NPRM* stated that these dramatic

¹⁰ See 47 CFR § 2.106, Table of Frequency Allocations.

¹¹ See Letter from the Assistant Secretary for Communications and Information, United States Department of Commerce, to Chairman Hundt, received November 2, 1995.

¹² See Final Acts of the World Radiocommunication Conference (WRC-95), Geneva, 1995. The United States, by signing the Final Acts with declarations, is obligated to apply provisionally the subject modifications of the Radio Regulations, as of the dates identified in the Final Acts and to the extent consistent with U.S. law, until either (1) it deposits an instrument of ratification with the International Telecommunications Union (after ratification by the President) in which case U.S. rights and obligations under the Radio Regulations are modified, or (2) it informs the International Telecommunications Union that it does not accept the Final Acts in which case the United States retains its preexisting rights and obligations under the Radio Regulations to which it is party.

developments in digital technology have stimulated a need for spectrum to be used for wireless interconnection within and among these networks. The Commission tentatively concluded that providing additional spectrum for unlicensed wideband operation would benefit a vast number of users, including educational, medical, business, and industrial users. Further, the Commission recognized that unlicensed access to this spectrum would permit educational institutions to form inexpensive broadband wireless computer networks between classrooms, thereby providing cost-effective access to an array of multimedia services on the Internet. In addition, the *NPRM* requested comment on whether new U-NII operations should include longer-range community networks.

8. *Comments.* The Commission's proposal to provide spectrum to accommodate U-NII devices is strongly supported by the majority of the commenters ("U-NII proponents"). The U-NII proponents include a variety of potential users, some of whom represent educational, medical, business, or consumer interests. U-NII proponents argue that U-NII devices would facilitate connections among computers, televisions, appliance automation products, and on-premises network cable or telephone company access points within homes, schools and health care facilities.¹³ Further, they submit that unlicensed devices could potentially satisfy a collection of communications needs that otherwise would probably remain unmet if free and open consumer access to spectrum were not available. For example, Motorola states that licensed operations generally involve an expansive infrastructure needed to provide a level of reliability and coverage for a specific communications need. It argues that development of these systems requires a significant investment unlikely to be made under an unlicensed regime. In contrast, unlicensed devices do not have to have the same level of reliability and can operate both as standalone and as an adjunct to wired and licensed wireless networks.¹⁴

9. Additionally, U-NII proponents argue that U-NII devices will provide communications that are flexible, mobile, have high data rates, and are low cost. They contend that existing wireless allocations and wireline alternatives may each be capable of providing some of these attributes, but not all of them. They contend that although some communication paths can be provided on wired networks or through currently allocated spectrum (like unlicensed Personal Communications Services ("U-PCS")), those capabilities are inadequate to meet communications needs in a large and growing number of circumstances because they are not capable of providing the necessary data rates and do not have a sufficient amount of spectrum available to meet all of the needs.¹⁵ Specifically, they argue that U-PCS does not provide sufficient capacity, wired networks lack flexibility and mobility, and other licensed wireless services are too costly. For example, Rockwell

¹³ See Motorola Comments at 1.

¹⁴ See Motorola Comments at 1.

¹⁵ See Northern Telecom, Inc Comments at 4 and Apple Reply at 5. We note that U-PCS has access to 30 megahertz of spectrum at 1910-1930 MHz and 2390-2400 MHz.

International Corporation ("Rockwell") claims that current unlicensed wireless systems are limited to data rates of about 2 megabits/second ("Mbits/sec"), far short of the 20 Mbits/sec and higher data rates necessary to support multimedia applications.¹⁶

10. U-NII proponents claim that unlicensed devices governed by flexible technical rules would enable the provision of a wide range of multi-media broadband digital communications at substantially lower costs than those offered by wired and licensed-wireless networks. For example, the joint comments of Educators¹⁷ support the proposal because U-NII devices could function as unlicensed LAN facilities that would be capable of providing the last-mile loop within educational settings in a cost effective manner.¹⁸ Educators claim that an affordable and convenient method for internal distribution of digital communications, such as would be provided by U-NII devices, would be embraced by the educational community; thus, the use of U-NII devices would likely extend into classrooms and other learning sites. Educators state that they are currently using the existing telecommunications infrastructure to deliver their services to some learning sites, but they face enormous financial and technical obstacles in distributing Internet access, data, voice or video services within these sites to the individual classrooms where they are needed.¹⁹ Further, Apple estimates that the cost of wiring America's K-12 schools would be \$50 billion, while equivalent wireless connections would cost substantially less. Apple adds that even though 30 to 50 percent of America's schools have access to the Internet, only two to five percent of America's classrooms have such access.²⁰ Additionally, comments from consumers and Internet service providers argue that it is extremely important for all individuals, particularly in remote, insular and rural areas, to be able to access the Internet inexpensively.²¹

11. Some U-NII proponents argue that the benefits of the NII will not be fully realized without the use of longer range community networks, as originally proposed by Apple, and that spectrum should be made available for such operations.²² They argue that

¹⁶ See Rockwell Comments at 2.

¹⁷ California State University, Education Network of Maine, University of Maine System, Network for Instructional TV, Inc., San Diego County Superintendent of Schools, South Carolina Educational Television Commission, and State of Wisconsin--Educational Communications Board (collectively, the "Educators").

¹⁸ See Educators' Comments at 2.

¹⁹ See Educators' Comments at 2-4.

²⁰ See *supra*, NPRM at para. 14.

²¹ See, e.g., electronic filed comments of Jim Martindale, Mike Renfro, and Jean Armour Polly.

²² See Microsoft Comments at 5, the joint comments of the National School Board Association, Media Access Project, National Education Association, American Association of School Administrators, and People for the American Way (Joint Commenters) Comments at 5, and Consumer Electronics Manufacturers Association (CEMA)

there is a need for low cost, flexible, easily implemented means of communications networks spanning rural areas and extending information access throughout smaller municipalities. They also claim these networks are needed to unify school, library and hospital districts with broadband data connections but that, currently, longer distance connections are often unavailable or prohibitively expensive.²³ Specifically, Apple states that many schools and individuals do not have local access to the Internet and would have to pay long distance charges for such access. It claims that the needed T-1 connections may cost from hundreds to tens of thousands of dollars annually and often have high up-front costs and/or per minute charges.²⁴ Apple and other supporters of the community network concept state that no other technology serves the needs for wide-bandwidth, low-cost communications that would be served by community networks. Apple claims that the ISM bands at 900 MHz, 2.4 GHz, and 5.8 GHz do not include sufficient spectrum to accommodate high speed connections.

12. The Consumer Electronics Manufacturers' Association ("CEMA") and Motorola, Inc. ("Motorola") state that unlicensed longer range U-NII devices will not supplant licensed microwave facilities, but should be viewed as a complement to, rather than a replacement for, licensed services.²⁵ Further, Mulcay Consulting Associates ("Mulcay") asserts that the Commission should facilitate competition to licensed longer range communications services by providing for unlicensed community networks. Mulcay argues that, over the past 20 years, the computer industry, with the benefits of open competition and unhindered innovation, has enjoyed a performance-to-price ratio that has improved by several orders of magnitude. However, over the past 20 years, the corresponding improvement in the performance-to-price ratio of transmission equipment and services has been minimal because there has been no meaningful competition to local loop common carriers and because of restrictive regulations governing the use of radio frequency ("RF") spectrum.²⁶

13. On the other hand, parties with incumbent or proposed operations in the bands addressed in this proceeding argue that there has not been a sufficient demonstration of need for new unlicensed U-NII devices. For example, L/Q Licensee, Inc. ("L/Q"), an MSS applicant, argues that no U-NII proponent provided a demonstration of the market demand for new U-NII devices or an estimate of when such demand would materialize.²⁷ In addition to general opposition to providing spectrum for all U-NII devices, a number of parties oppose

Comments at 5.

²³ See Apple Comments at 2.

²⁴ See Apple Comments at 5.

²⁵ See Motorola Comments at ii and CEMA Reply at 4.

²⁶ See Mulcay Reply at 4-5.

²⁷ See L/Q Comments at 12, 14.

Apple's idea for longer range community networks. For example, Pacific Telesis Group ("PacTel"), a Regional Bell Operating Company, argues that unlicensed longer range links would violate requirements for regulatory parity between wireless services and increase the potential for interference from U-NII devices.²⁸ Similarly, the American Radio Relay League, Inc. ("ARRL") states that longer range community networks are not consistent with the typical low-power operations authorized by Part 15 and such high powered operations would not be in accordance with the licensing requirements of the Communications Act, which it claims require that systems with a significant interference potential be operated on a licensed basis.²⁹

14. Additionally, fixed microwave manufacturers argue that unlicensed longer range community networks are not needed because existing licensed microwave services can adequately supply the needed communications capabilities. For example, the Fixed Point-To-Point Communications Section, Network Equipment Division of the Telecommunications Industry Association ("TIA") states that unlicensed links longer than 1-2 km in length are not needed because fixed services in higher frequency bands can provide inter-community links more efficiently by utilizing existing equipment and related technologies, which are less expensive, more reliable and provide greater capacity and higher speeds than unlicensed equipment.³⁰ TIA adds that 1-2 km U-NII links would be sufficient to promote compatibility with High Performance LAN ("HIPERLAN") operations. Additionally, Part 15 spread spectrum interests argue that unlicensed community networks can presently be provided by longer range spread spectrum operations under Section 15.247 without the sharing problems associated with non-spread spectrum techniques.³¹

15. *Decision.* We find that there is a need for unlicensed wireless devices that will be capable of providing data rates as high as 20 Mbits/sec to meet the multimedia communication requirements envisioned by the U-NII proponents.³² To achieve these high data rates at a reasonable cost, we believe that these devices must use broad bandwidths of up to 20 megahertz each and therefore these devices must have access to a substantial amount of spectrum to accommodate a number of devices within the same area.³³ Further, we believe

²⁸ See PacTel Comments at 3.

²⁹ See ARRL Comments at 5-9.

³⁰ See TIA Comments at 2.

³¹ See Cylink Comments at 6 and Western Multiplex Comments at 2.

³² See, e.g., Apple Comments at 4-5; Hewlett-Packard Comments at 2, 6; Northern Telecom, Inc Comments at 10; Rockwell Comments at 2; and WINForum Comments at 7-14.

³³ We have assumed up to a 20 megahertz channel requirement for U-NII devices that will transmit data rates of 20 Mbits/sec, which equates to a spectrum efficiency of 1 Mbits/sec per hertz. We recognize that a number of commercially available transmitters and systems are capable of higher data rates per hertz, but they also are generally capable of achieving higher signal to noise ratios because they are not as restricted in power as U-NII devices.

that accessibility to a substantial amount of spectrum is necessary for these devices to develop and mature to their full potential. The record in this proceeding supports our belief that recent developments in digital technologies have greatly increased the requirements for transferring large amounts of information and data in relatively short time frames from one network or system to another.³⁴ Specifically, we note that computers have much faster central processing units and substantially increased memory capabilities, which have increased the demand for devices that can more quickly transfer larger amounts of data. Further, digital equipment is capable of switching and directing large amounts of information within networks. In addition to these technical advances in hardware capability, there has been substantial growth in the use, size, and complexity of digital networks as well. Many of these networks are not only growing internally in the amount and types of data they contain, but are also increasingly being used in combination and interaction with other such networks.

16. Further, it is clear from the record that educational institutions, business, industry, and consumers are all looking for ways to begin taking advantage of the innovative technological developments that promise the delivery of multimedia services comprising voice, video, imaging, and data. We agree with the commenters who argue that existing wireline and wireless services, in some cases, may not be able to meet all of the communications requirements and demands that these technological developments bring in a cost-effective manner.³⁵ The record here shows that U-NII devices may be able to provide cost-effective communications services that will both complement and compete with existing services.³⁶ For example, the spectrum and associated regulatory structure developed for U-PCS devices were not designed to handle broadband multimedia computer applications. Equipment in the U-PCS bands is limited to a maximum bandwidth of 2.5 megahertz and would not support data rates of 20 Mbits/sec or greater as envisioned for U-NII devices. Further, if we were to authorize broadband, high data rate equipment to use the 30 MHz of spectrum available for U-PCS, that spectrum would quickly become congested and would have limited use for the types of operations it is intended to accommodate. Additionally, we believe that as the NII and other telecommunications infrastructures grow, new communications alternatives that are flexible and inexpensive will be needed to assure delivery of information and services to all members of our society, regardless of income or location.

Accordingly, we believe our assumed 20 megahertz channel per device for these high data rates is appropriate due to the low powers of U-NII devices.

³⁴ See, e.g., Information Technology Industry Council Comments at 2-4, Northern Telecom, Inc Comments at 3, and Apple Reply at 2-3.

³⁵ See e.g., WINForum Comments at 5-6, Apple Comments at 4, and Nortel Comments at 4.

³⁶ See Motorola Comments at ii and CEMA Reply at 4.

17. Accordingly, we find that it is appropriate to provide spectrum for wireless unlicensed digital network communications devices to meet the foreseeable communications demands of multimedia network systems resulting from developments of new digital technologies. We believe that this will facilitate rapid and inexpensive wireless access to information resources by educational institutions, business, industry, and consumers. We also believe that making this spectrum available for U-NII devices will further the Commission's mandate, in Section 257(b) of the Communications Act, to promote vigorous competition and technological advancement.³⁷ For example, allowing unlicensed devices access to the 5.15-5.35 GHz and 5.725-5.825 GHz bands would permit educational institutions to form inexpensive broadband wireless computer networks between classrooms, thereby providing cost-effective access to an array of multimedia services on the Internet. In addition, unlicensed wireless networks could help improve the quality and reduce the cost of medical care by allowing medical staff to rapidly and inexpensively obtain patient data, X-rays, and medical charts.

18. While we agree that some of the communications requirements, particularly the longer range community networks, could be partially accommodated through licensed services, such as the fixed point-to-point and point-to-multipoint services, we believe that the unlicensed devices contemplated here will both complement and provide a cost-effective alternative to such services. They may also provide an additional and competitive means for educational institutions, libraries, and health care providers for rural areas to connect to basic and advanced telecommunications services, as envisioned by the Telecommunications Act of 1996.³⁸ Given that the communications needs of these institutions are expected to be very great and that the technical means best suited to meeting these needs may vary considerably from institution to institution, we believe it desirable that a variety of communications options, including unlicensed operations such as U-NII devices, be available to address these needs. Accordingly, we believe that some spectrum should be made available to accommodate some of the longer range community network requirements envisioned by the U-NII proponents.³⁹

³⁷ See 47 U.S.C. § 257(b) ("the Commission shall seek to promote the policies and purposes of this Act favoring... vigorous economic competition, technological advancement, and promotion of the public interest, convenience, and necessity.").

³⁸ See Section 254(b) of the Communications Act of 1934, as amended by Section 101 of the Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (1996), at Section 101; *see also* Section 706 of the Telecommunications Act of 1996.

³⁹ As addressed below, the power limits we are adopting here will generally limit the longer range community networks to several kilometers.

B. *Spectrum to Be Made Available*

19. In the *NPRM*, the Commission proposed to make available 350 megahertz of spectrum at 5.150-5.350 GHz and 5.725-5.875 GHz to provide for a number of U-NII operations in each geographical area to meet the growing demand for new high speed data communications. The Commission stated that spectrum below 5 GHz is too congested, and that higher frequencies would both increase the cost of equipment and have even more limited propagation characteristics than 5 GHz. Additionally, the Commission tentatively concluded that U-NII devices could share spectrum in the 5 GHz range with other users.

20. *Comments.* The U-NII proponents support providing 350 megahertz of spectrum in the 5 GHz range for these devices. They argue that 350 megahertz of spectrum is needed to realize the full potential of today's broadband information technologies and to encourage further innovation in the delivery of new broadband digital communications.⁴⁰ They claim that providing unlicensed broadband devices access to this amount of spectrum will meet the needs of multiple users at a common location and should be sufficient to provide for open entry and equal access by all unlicensed devices.⁴¹ Further, they claim that this amount of spectrum is needed to provide an environment for robust development and growth, and to permit the communications infrastructure to keep pace with future computer advancements. They also argue that 350 megahertz is required to link mobile users and those not served by the broadband wireline infrastructure. U-NII proponents further argue that 350 megahertz is necessary for wide bandwidth U-NII networks because these devices will have to share the spectrum with other users, such as MSS, Amateur, and ISM.⁴² Motorola adds that the proposed bands will help establish U.S. leadership in an ever-increasing global market for telecommunication products.⁴³ Similarly, Northern Telecom, Inc. ("Nortel") notes that the proposed bands would align the spectrum available domestically for U-NII devices with the spectrum available for European HIPERLAN systems.⁴⁴

⁴⁰ See Rockwell Comments at 2, WINForum Reply at 6, and Hewlett-Packard Comments at 2.

⁴¹ See Motorola Comments at 2 and Hewlett-Packard Comments at 2.

⁴² See, e. g., WINForum Reply at 6.

⁴³ See Motorola Comments at 2.

⁴⁴ See Nortel Comments at 4-5. HIPERLAN is the new European standard for radio LANs currently being formulated by ETSI RES10 for operation at 5 GHz and 17 GHz. It is intended to be a suitable radio replacement of wired LANs and for ad hoc networking providing a user data rate of 10-20 Mbits/sec. The European Radiocommunications Committee ("ERC") identified the 5.15-5.25 GHz band for HIPERLAN throughout Europe and the 5.25-5.30 GHz band for HIPERLAN on national basis. See ETSI Final Draft, pr ETS 300 652, June 1886. We also note the European Space Agency has expressed concerns about sharing the 5.25-5.35 GHz band between Earth Exploration Satellite Service operations and HIPERLAN. See Letter from Edoardo Marelli of the European Space Agency to SFCG Delegates regarding HIPERLAN and C-band SAR sharing Analysis, dated March 6, 1996.

21. WINForum, however, argues that even more spectrum will be needed for U-NII broadband unlicensed devices. WINForum urges the Commission to consider future expansion of the U-NII band above 5.35 GHz as operations mature and demand increases.⁴⁵ In this regard, WINForum estimates an eventual need for 450 megahertz of spectrum for wireless multimedia networks.

22. Incumbent users of the 5 GHz band oppose making available the entire 350 megahertz of spectrum for unlicensed U-NII devices. While most incumbent users are not opposed to opening some spectrum for broadband unlicensed devices, they urge the Commission not to provide such spectrum in their own respective bands, alleging concern about potential interference from the unlicensed devices to their operations. Further, they state that WINForum originally requested only 250 megahertz of spectrum, and Apple only 300 megahertz, and that the record does not demonstrate a need for 350 megahertz. PacTel argues that 350 megahertz is excessive for unlicensed devices with unproven technology and untested market acceptance, that initially opening 100 megahertz of spectrum would be sufficient for the U-NII operations to develop, and that additional spectrum could be provided as needed.⁴⁶

23. Some incumbent users also argue that the record does not demonstrate that spectrum for broadband unlicensed devices should be located at 5 GHz. In this regard, commenter L/Q argues that unlicensed U-NII devices do not have to use spectrum in the 5 GHz range. They indicate that 185 megahertz of Government spectrum below 5 GHz will be made available for commercial use before the year 2004. They also assert that spectrum above the 5 GHz range could be used affordably by unlicensed devices, given that equipment prices will fall as the devices become widespread.⁴⁷ Further, Cylink Corporation ("Cylink") urges the Commission to explore whether there are other bands that are more appropriate than 5 GHz for medium-range, point-to-point communications.⁴⁸ For example, Cylink urges that the Commission consider use of the millimeter wave bands to provide wireless LAN communications for educational and industrial campus areas;⁴⁹ the 2.4 and 5.8 GHz ranges for

⁴⁵ See WINForum Reply at 6.

⁴⁶ See PacTel Comments at 3.

⁴⁷ See L/Q Comments at 14.

⁴⁸ See Cylink Comments at 2.

⁴⁹ See *First Report & Order and Second Notice of Proposed Rule Making*, ET Docket No. 94-124, 11 FCC Rcd 4481 (1996).

outdoor point-to-point spread spectrum devices;⁵⁰ and the 59-64 GHz band for unlicensed high speed communications.⁵¹

24. MSS interests argue that the Commission should not permit U-NII devices, particularly longer range devices intended to serve community networks, in the 5.15-5.25 GHz band because such operations would interfere with MSS feeder links.⁵² Additionally, L/Q challenges the validity of the claim that U-NII devices need access to the 5.15-5.35 GHz band to be compatible with HIPERLAN. They assert that HIPERLAN is still only a proposal that may not ultimately be adopted in Europe.

25. Regarding the upper band, 5.725-5.875 GHz, incumbent interests argue that this spectrum is not needed for U-NII devices because the 200 megahertz proposed in the 5.15-5.35 MHz band should be sufficient.⁵³ Parties that manufacture unlicensed spread spectrum devices under Section 15.247 of the Commission's rules argue that the upper band should not be made available because U-NII devices might interfere with existing unlicensed spread spectrum devices operating in this band.⁵⁴ They oppose permitting non-spread spectrum U-NII devices to operate in the upper band without detailed technical analysis and equipment testing to determine which U-NII applications could be implemented, and what technical specifications will be needed to avoid interference to spread spectrum operations.⁵⁵ Amateur interests share a similar concern, arguing that U-NII devices would cause harmful interference to amateur operations in this band. For example, the Southern California Repeater and Remote Base Association ("SCRRBA") argues that the 5.15-5.30 GHz band would better accommodate U-NII devices because it would allow for the development of equipment consistent with HIPERLAN.⁵⁶ SCRRBA, however, states that the upper band could be used on a limited basis by U-NII devices if adequate technical limits (*i.e.*, spread spectrum requirement, short distance, and power limit similar to U-PCS) are imposed and if the secondary allocation of the amateur service in this band were upgraded to a primary

⁵⁰ See *Notice of Proposed Rule Making*, ET Docket No. 96-8, 11 FCC Rcd 3068 (1996).

⁵¹ *Supra*, note 49.

⁵² See Airtouch Reply at 2, Comsat Corporation and ICO Global Communications Reply at 2, and L/Q Reply at 4.

⁵³ See Cylink Comments at 4, Western Multiplex Comments at 3 and Wireless Field Test for Education Project ("WFTEP") Comments at 3.

⁵⁴ See Western Multiplex Comments at 3-4, Metricom Reply at 6 and Cylink Reply at 12.

⁵⁵ See, *e.g.*, Cylink Comments at 8.

⁵⁶ See SCRRBA Reply at 9.

allocation.⁵⁷ The San Bernardino Microwave Society ("SBMS"), on the other hand, opposes any U-NII operations in the upper band, arguing that these devices cannot share with amateur weak-signal operations.⁵⁸

26. Finally, several parties oppose allowing U-NII operations in the 5.85-5.875 GHz portion of the spectrum. The Federal Highway Administration ("FHWA") and the Intelligent Transportation Society of America ("ITS") state that U-NII devices at 5.85-5.875 GHz would interfere with their plans to seek an allocation of the 5.85-5.925 GHz band for Dedicated Short Range Communications ("DSRC").⁵⁹ Further, Resound Corporation ("Resound"), a manufacturer of hearing health care products, argues that the 5.85-5.875 GHz band should not be provided for U-NII operations, because such operations would interfere with the current use of this spectrum for low power hearing assistance devices permitted under Section 15.249.⁶⁰

27. *Decision.* We continue to believe that it is appropriate to provide unlicensed devices with access to a substantial amount of spectrum at 5 GHz to accommodate the demand by educational, medical, business, industrial and consumer users for broadband multimedia communications. We are also cognizant, however, of the need for U-NII devices to share the spectrum with primary services without causing radio interference to those services. We believe that both of these concerns can be accommodated by adopting appropriate technical restrictions for U-NII devices, particularly transmit power and out-of-band emission limits (see technical discussion below), and by avoiding portions of the spectrum where sharing would be particularly difficult. Accordingly, we will make 300 megahertz of spectrum available for U-NII devices. Specifically, we are providing U-NII devices access to three 100 megahertz bands at 5.15-5.25 GHz, 5.25-5.35 GHz and 5.725-5.825 GHz. We recognize that this is less than the 350 megahertz that was proposed in the *NPRM*, but we believe that this amount of spectrum provides an appropriate balance between spectrum sharing concerns and providing sufficient spectrum to satisfy the needs of U-NII devices.

28. We believe that 300 megahertz of spectrum will provide sufficient spectrum to allow the full potential of broadband multimedia technologies to be realized. This spectrum

⁵⁷ See SCRRBA Comments at 9.

⁵⁸ See SBMS Reply at 2-5.

⁵⁹ See FHWA Comments at 2-3 and ITS Comments at 2. FHWA's comments state that DSRC communications could encompass several applications that require guaranteed channel access. For example one such application involves implementation with roadside speed- and location-sensing equipment, DSRC communications equipment, in-vehicle signing equipment and trajectory computing and control electronics. Using these components, as vehicles approach an intersection, their speed and location are compared with the traffic signal status and potential collision conditions are identified. DSRC is then used to warn drivers of danger.

⁶⁰ See Resound Comments at 4.

should provide for open entry and equal access by all such devices and to allow access to the spectrum by multiple users at a common location using a variety of different devices. In this regard, we note that these broadband devices each may require 20 to 25 megahertz channel bandwidth to provide the high data rates envisioned by the petitioners.⁶¹ Furthermore, as discussed in greater detail in Section C below, the different sharing environments applicable to the three 100 megahertz sub-bands, 5.15-5.25, 5.25-5.35, and 5.725-5.825 GHz, require that U-NII operations comply with discrete technical standards for each sub-band.

29. This action will also open opportunities for American industry to be competitive in the global market for these new telecommunication products. Specifically, providing access to the 5.15-5.30 GHz band would permit U-NII devices to be compatible with the European HIPERLAN and would allow American industry flexibility to create products for both markets.⁶²

30. We also believe that the 300 megahertz of spectrum we are providing for U-NII devices avoids the use of spectrum that would be particularly difficult to share with primary operations. Specifically, as addressed below, we believe that U-NII devices can share with proposed and existing services in these bands including the MSS feeder link operations that may use the 5.15-5.25 GHz band. On the other hand, U-NII devices will not have access to spectrum used by microwave landing systems ("MLS") operated by the FAA in the 5.0-5.15 GHz band. Additionally, U-NII devices will not have access to the 5.825-5.875 GHz band. This will avoid potential interference with low power Part 15 hearing aid devices and potential ITS operations in the 5.850-5.875 GHz band, FSS operations in the 5.850-5.925 GHz band, and amateur operations in the 5.650-5.725 and 5.825-5.925 GHz bands.

31. We are not persuaded by arguments that U-NII devices should be accommodated in spectrum other than the 5 GHz bands. With regard to the argument that U-NII devices could use Government spectrum below 5 GHz that will be made available in the future for commercial use, we note that this amount of spectrum is substantially less than the amount we are here making available and is distributed over a wide range of frequency bands that would make the design of equipment difficult and expensive. We note that those bands will be the subject of future rule making proceedings that will determine the types of operations for which those bands may be used. We are also unpersuaded that spectrum above the 5 GHz range, particularly the millimeter wave bands above 40 GHz, could be used by unlicensed devices as easily or be made available as quickly as the 5 GHz bands. We note that signals at these higher frequencies have propagation constraints that will reduce the communication distances of devices operating at equal powers. Further, equipment that

⁶¹ See, e.g., Hewlett-Packard Comments at 6, Nortel Comments at 10, Rockwell Comments at 2, 3Com Comments at 5, and WINForum Comments at 7.

⁶² See *supra*, n. 44.

operates at a higher frequency is typically more expensive than equipment that operates at a lower frequency range.

C. *Technical Standards*

1. *General*

32. In the *NPRM*, we proposed rules to provide the maximum technical flexibility in the design and operation of U-NII devices, to ensure that they do not cause harmful interference to incumbent and future operations, and to facilitate basic spectrum sharing among unlicensed devices. We proposed a maximum peak power limit of 100 milliwatt ("mW") (-10 dBW) Equivalent Isotropically Radiated Power ("EIRP") for both the upper and lower 5 GHz U-NII bands. We also requested comment on whether to permit operations at up to 1 watt ("W") (0 dBW) of transmitter output power within the upper band in order to facilitate community networks. Additionally, we did not propose limits on channelization or modulation efficiency, but did request comment on these issues. Further, we proposed limits on emissions outside the bands of operation. Specifically, we proposed to require all emissions occurring from U-NII devices outside of the authorized bands to be attenuated by at least 50 dB or to the radiated emission limits set forth in Section 15.209,⁶³ whichever is the lesser attenuation.⁶⁴ In addition, we proposed to require any emissions occurring in the restricted bands⁶⁵ to comply with the radiated emission limits set forth in Section 15.209. We also proposed to require any unwanted emissions to comply with the general field strength limits set forth in Section 15.209. Finally, we proposed to require that any U-NII devices using an AC power line must also comply with the conducted limits set forth in Section 15.207.⁶⁶

33. *Comments.* The commenters strongly support the adoption of only those technical regulations, such as power limits and emission limits, needed to prevent interference from U-NII devices to incumbent services.⁶⁷ They claim that this would provide technological flexibility in the design and types of new equipment that can be manufactured and would correspondingly provide consumers with greater choices in U-NII devices and communications options.

⁶³ See 47 CFR § 15.209.

⁶⁴ See *supra*, *NPRM* at para. 49.

⁶⁵ Only spurious Part 15 emissions are permitted in restricted bands. The restricted frequency bands are those allocated for services involving safety-of-life or for services that are required by the nature of their operations to use signals received at very low received levels. See 47 CFR § 15.205. See, also, *First Report and Order*, GEN. Docket No. 87-389, 4 FCC Rcd. 3493 (1989).

⁶⁶ See 47 CFR § 15.207.

⁶⁷ See, e.g., CEMA Reply at 7, Educators Comments at 4, and WINForum Reply at 11.

34. *Decision.* We continue to believe that the best regulatory framework to facilitate the introduction of U-NII devices is one that provides the maximum technical flexibility in their design and operation by imposing only the minimum technical rules necessary to prevent harmful interference to primary operations and to provide for basic spectrum sharing among unlicensed devices. The adoption of such an approach is overwhelmingly supported by the record. We believe that adoption of minimum technical rules would not only permit unlicensed devices to operate successfully on a shared basis, but would also encourage maximum flexibility in the types and designs of unlicensed digital devices that could use this band. Accordingly, as addressed below, we are adopting the minimum technical regulations which we believe will most facilitate the introduction of U-NII devices, will adequately protect primary services, and will promote sharing among U-NII devices.⁶⁸ These rules specify power limits (in terms of peak power and power spectral density), emission limits, radio frequency hazard requirements, and other basic technical rules appropriate for unlicensed Part 15 operations. Further, as addressed below, we are not adopting a channeling plan, spectrum modulation efficiency requirement or a spectrum etiquette as we believe such technical standards are unnecessary at this time, could preclude certain technologies, and could unnecessarily delay implementation of U-NII devices.⁶⁹

2. *Power and Antenna Constraints*

35. *Comments.* The comments vary substantially with regard to the power and antenna gain limits that should be adopted to allow for reliable communications while protecting the incumbent 5 GHz services and allowing for sufficient frequency reuse among U-NII devices. Some U-NII proponents support our proposed maximum power limit for within-building and short-range LAN operations, but also claim that higher power will be needed for both local-area campus communications and for community area networks. Incumbent interests generally support the proposed 100 mW EIRP limit which, they argue, is necessary to protect incumbent operations.

36. Most U-NII proponents support allowing higher power and higher antenna gain in the U-NII spectrum. They claim that the propagation characteristics at 5 GHz are such that operation at power levels higher than the proposed limit is required to provide reliable communications for most local-area networks and for longer-range networks.⁷⁰ They state that the signal attenuation caused by walls is one of the primary reasons why higher power is needed for LANs. Higher power, they state, is also needed for community networks to achieve reliable communications over the necessary distances. For example, WINForum argues that, in order to meet on-premises communication requirements, the maximum

⁶⁸ See para. 35-54 below.

⁶⁹ See para. 55-71 below.

⁷⁰ See, e.g., Benton Foundation and Computer Professionals For Social Responsibility ("Benton") Comments at 5 and Connectivity for Learning Coalition Comments at 3.

transmitter output power limit in the 5.15-5.35 GHz band should be 100-250 mW (-10 to -6 dBW), and directional antennas should be permitted with up to 6 dBi gain.⁷¹ It also suggests allowing use of even higher gain antennas, as long as the transmitter power is decreased on a dB-for-dB adjustment basis (*i.e.*, transmitter output power would be decreased by one dB for every dB increase in antenna gain). WINForum states that these maximum power and gain parameters would provide a desirable balance between permitting sufficient in-building signal penetration by U-NII devices and ensuring adequate interference protection to incumbent 5 GHz and other U-NII operations.

37. Apple supports adoption of a maximum transmitter output power of 100 mW (-10 dBW) in the 5.15-5.25 GHz band.⁷² Apple states that this power limit would protect incumbent operations and would allow the lower power band to be used for personal/portable type operations that would generally operate indoors. Apple also argues for a higher limit on transmitter output power in the 5.25-5.35 GHz and 5.725-5.825 GHz bands. Specifically, Apple states that we should set the power limit at 316 mW (-5 dBW), with unrestricted antenna gain in these bands. It claims higher power is needed in these bands to provide for fixed point-to-point operations that would meet the requirements of community networks.

38. WINForum also urges the Commission to adopt higher power and antenna gain limits for the upper band, 5.725-5.825 GHz. It notes that Part 15 spread spectrum devices in this band are currently authorized to operate with up to 1 W transmitter output power and with up to 6 dBi of antenna gain. Further, it notes that even higher power limits for spread spectrum devices are currently under consideration by the Commission in ET Docket 96-8.⁷³

39. Motorola recommends adoption of a maximum transmitter output power limit of 250 mW in the 5.15-5.35 GHz band, and 1 W in the 5.725-5.825 GHz band, for bandwidths equal to or greater than a certain threshold, *e.g.*, 25 megahertz. Motorola also supports allowing transmitter antenna gains of up to 23 dB in both bands, without any associated reduction in transmitter output power.⁷⁴ Motorola argues that directional transmitter antennas will provide reliable communications with lower risk of interference. It further states that U-NII device power limitations should be based on the output power spectral density to reduce interference concerns irrespective of the emission bandwidth. That is, transmitter output power should be reduced in direct proportion to any reduction in emission bandwidth below some threshold. With regard to community network links,

⁷¹ See WINForum Comments at 23-25.

⁷² See Apple Comments at 8. They also support adoption of the same 100 mW maximum transmitter output power limit for the 5825-5875 MHz band. Since we have decided not to make this spectrum available to U-NII devices, comments addressed to technical rules for this band are now moot.

⁷³ See *supra*, note 50.

⁷⁴ We note that 1 W transmitter power with 23 dBi gain would provide an EIRP of 200 W.

Motorola recommends that, consistent with the proposal in ET Docket No. 96-8, the Commission allow the use of even higher gain transmitter antennas whenever the transmitter output power is reduced by 1 dB for each 3 dB of antenna gain above 23 dB.⁷⁵

40. Mulcay points out that the proposed 100 mW (-10 dBW) EIRP limit is substantially lower than the European HIPERLAN standard of 1 W (0 dBW) EIRP. Mulcay states that the maximum transmitter output power limit for U-NII devices should therefore be raised to 1 W (0 dBW) EIRP to be consistent with the HIPERLAN limit. It claims this would facilitate U.S. firms' ability to compete in global markets.⁷⁶

41. Parties currently utilizing the 5 GHz spectrum generally support the 100 mW EIRP limit proposed in the *NPRM*.⁷⁷ NTIA recommends adoption of the 100 mW EIRP limit in the 5.15-5.25 GHz band to provide adequate interference protection to primary operations in that band. L/Q adds that U-NII operations at any higher power would degrade the sharing capacity in that band and would greatly increase their potential to cause harmful interference to FSS operations in the band.⁷⁸ L/Q also opposes allowing directional antenna use by U-NII devices operating in the band. It contends that though interfering signals from a directional antenna may not be received by all satellites overhead, they could certainly be received by satellites close to the horizon and, thus, FSS capacity to operate in the band could be impaired. The ARRL argues that permitting the power of U-NII operations to exceed 100 mW EIRP or permitting the use of high-gain antennas by non-spread spectrum U-NII devices would represent a significant departure from the underlying precepts of Part 15, which require unlicensed operations not to cause interference to other services. Although the ARRL opposes the operation of U-NII devices in the 5.725-5.825 GHz band, it states that if a 100 mW EIRP limit and a power spectral density limitation of 0.03 mW in any 3 kHz bandwidth were adopted, then U-NII devices should be able to share this band with incumbent operations.⁷⁹ Finally, entities with spread spectrum interests oppose the operation of higher power, non-spread spectrum U-NII devices in the upper band on the basis that such operations could prevent existing spread spectrum devices from sharing that band.⁸⁰

42. *Decision.* We find that the 100 mW power limit proposed in the *NPRM* is not sufficient to accommodate the range and scope of communications envisioned for U-NII

⁷⁵ See Motorola Comments at 8.

⁷⁶ See Mulcay Reply at 9.

⁷⁷ See Pacific Telesis Comments at 4, TIA Comments at 2, and ARRL Comments at 7.

⁷⁸ See L/Q Reply at 5.

⁷⁹ See ARRL Comments at 10.

⁸⁰ See Larus Comments at 2 and Cylink Reply at 5.

devices. We believe that increasing the U-NII device power limits will enable these devices to provide for a variety of operations including local areas networks, campus-type settings, or as part of community networks. At the same time, we recognize the need to ensure that primary operations are adequately protected from harmful interference. In this regard, we note that the primary users and the considerations that relate to interference with their operations, vary in different parts of the spectrum we are providing for U-NII devices. Specifically, the 5.15-5.25 GHz band will be shared with MSS feeder links; the 5.25-5.35 GHz band will be shared with Government radiolocation operations; and the 5.725-5.825 GHz band will be shared with Government radiolocation, Amateur, ISM, and other Part 15 operations. Therefore, the sharing environment for U-NII devices will be different for each of these three 100 megahertz segments. We find a balance between providing sufficient power limits for U-NII devices and protecting primary operations may be struck by adopting different power levels for U-NII devices in each of the three 100 megahertz bands. This approach will provide the needed flexibility to allow U-NII proponents to design and manufacture equipment to meet a variety of communications needs while ensuring a successful spectrum sharing environment with other spectrum users.

43. Accordingly, we will divide the 300 megahertz available to U-NII devices into three bands of 100 megahertz each and will establish the following maximum U-NII device power limits for each band: a) in the 5.15-5.25 GHz band, the maximum peak transmitter output power limit will be 50 mW with up to 6 dBi antenna gain permitted, which equates to 200 mW EIRP; b) in the 5.25-5.35 GHz band, the maximum peak transmitter output power limit will be 250 mW with up to 6 dBi antenna gain permitted, which equates to 1 W EIRP; and c) in the 5.725-5.825 GHz band, the maximum peak transmitter output power limit will be 1 W with up to 6 dBi directional antenna gain permitted, which equates to 4 W EIRP. To permit manufacturers flexibility in designing U-NII equipment, we will permit the use of higher directional antenna gain provided there is a corresponding reduction in transmitter output power of one dB for every dB that the directional antenna gain exceeds 6 dBi.

44. In the 5.15-5.25 GHz sub-band, we believe a 50 mW peak output power with up to 6 dBi gain antenna will provide U-NII devices great flexibility in how this band is used. Specifically, these power limits will allow U-NII devices to provide a variety of short-range communications, such as those between computing devices (such as computers, servers, printers, etc.) within a very local area, such as in a room or in adjoining rooms. We also believe that restricting U-NII devices to this low power will allow U-NII devices to share this band with co-channel MSS feeder link operations. In this regard, we note that the initial European Conference of Postal and Telecommunications Administrations ("CEPT") studies conclude that HIPERLAN systems, which have technical characteristics similar to those of U-NII devices, can share this band with the MSS operations without causing harmful interference to the MSS feeder links.⁸¹ (See Section E "*Spectrum Sharing Considerations*")

⁸¹ See CEPT Recommendation T/R 22-06 (Madrid 1992); see also Proposed Modification of CEPT Recommendation T/R 22-06.

below.) While some commenters have argued that based on the CEPT studies that U-NII devices could operate at higher powers than we are adopting without causing interference, we recognize that since the CEPT study was made Globalstar has changed some of the parameters of its system and that its MSS feeder links potentially could be more susceptible to interference. In any event, we believe the power we are adopting is appropriate to ensure that U-NII devices do not cause harmful interference to MSS feeder link operations. We are also restricting U-NII use of this band to indoor operations. This will provide additional protection to co-channel MSS operations due to the attenuation of U-NII device signals as they pass through the walls and ceilings of buildings. Accordingly, we believe this power limit, along with the restriction on outdoor operations, will provide the desired balance of providing sufficient power for U-NII devices in this band, high frequency reuse, great flexibility in the types of U-NII operations that are accommodated in this band, and protection of co-channel MSS operations.

45. In the 5.25-5.35 GHz sub-band, we are adopting a higher maximum peak transmitter input power limit of 250 mW, along with the associated higher power spectral density limit noted below. We are not restricting U-NII devices to indoor operations in this band because it will not be shared with MSS operations. We believe that U-NII operations with a peak transmitter output power of up to 250 mW and a directional antenna with up to 6 dBi of gain will be sufficient to accommodate communications within and between buildings, such as are envisioned for campus-type LANs. The only operations in this band are Government radiolocation systems (radar), and NTIA has supported allowing higher power for U-NII operations in this portion of the band. These power and antenna gain limits are comparable to the 1 W EIRP limit used for HIPERLAN and therefore should provide manufacturers with economies of scale in developing equipment useable in both the domestic and international markets.

46. In the 5.725-5.825 GHz band, we note that spread spectrum Part 15 devices are already authorized to operate with 1 W transmitter peak output power and with up to 6 dBi gain transmitting antennas. Accordingly, we are authorizing similar peak power and antenna gain parameters for U-NII devices in this band. We believe that U-NII operations that comply with this power limit will be able to provide community networks with a typical range of several kilometers. Further, we believe that longer-range communications could be possible in areas with a low interference environment (*i.e.*, rural areas) where high gain receive antennas could be used.⁸² (Such antennas do not affect the transmitted emission level or EIRP.) We recognize that the commenters recommend that we allow the use of even higher gain transmitting antennas in this band. However, the record in this proceeding does not provide enough technical support for us to conclude that U-NII devices with 1 W transmitter power and high gain transmit antennas would not cause interference to the primary service, Government radiolocation. Specifically, NTIA has expressed concern about higher

⁸² High gain receive antennas would not be useful in areas where the ambient noise level is high, such as areas where there are a large number of U-NII devices operating co-channel.

powers in this band and supports further experimentation before either higher power or gain is authorized.

47. In ET Docket No. 96-8, we are currently considering whether to authorize the use of transmitting antennas with higher gain for Part 15 spread spectrum operations in this band. If we decide in that proceeding to permit the use of higher antenna gain for spread spectrum operations, we may consider similar action for U-NII devices in this band in a separate rule making. However, we note that permitting use of high gain antennas with U-NII devices without requiring an equal reduction in power could have a significant impact on the interference environment in this band, and this issue would have to be addressed should a further rule making be initiated.

48. With regard to sharing this band with amateur operations, we believe that U-NII devices will cause little interference to amateur operations because of the relatively low power with which U-NII devices will operate. Further, we note that the amateur service has access to all spectrum within the 5.65-5.925 GHz range. We therefore believe that amateur operations will be able to avoid using frequencies within the 5.725-5.825 GHz band that are available to U-NII devices, in those rare cases where such avoidance may be necessary.

49. Additionally, in all three bands we are adopting peak power spectral density limits to ensure that the power transmitted by U-NII devices is evenly spread over the emission bandwidth. Specifically, we will require U-NII devices to decrease transmitter output power proportionally to any decrease in emission bandwidth below 20 MHz. These requirements will decrease the potential for interference to other services and will encourage the use of the U-NII bands for the broadband operations for which they are intended. For U-NII devices operating with less than 20 megahertz of emission bandwidth, we will limit power spectral density as follows: a) in the 5.15-5.25 GHz band, the transmitter peak power spectral density will be 2.5 mW/MHz for an antenna gain of 6 dBi; b) in the 5.25-5.35 GHz band, the transmitter peak power spectral density will be 12.5 mW/MHz for an antenna gain of 6 dBi; and c) in the 5.725-5.825 GHz band, the transmitter peak power spectral density will be 50 mW/MHz for an antenna gain of 6 dBi.⁸³ Finally, to allow manufacturers flexibility in designing U-NII devices, we will allow operations with antenna gains exceeding 6 dBi if the peak power spectral density is reduced by the same amount the directional antenna gain exceeds 6 dBi.

50. In the 5.15-5.25 GHz band, we will require transmitting antennas to be an integral part of the U-NII device. This will ensure that our authorized power limits are not exceeded in this band. In the 5.25-5.35 GHz and 5.725-5.825 GHz bands, we shall require that the U-NII device use a permanently attached antenna or an antenna that uses a unique

⁸³ These power spectral density requirements shall be measured with a spectrum analyzer having a resolution bandwidth of 1 megahertz.

coupling to the U-NII devices in accordance with Section 15.203(a) of the rules.⁸⁴ These requirements will limit potential interference to other systems and will provide for greater frequency reuse by U-NII devices.

3. *Emissions Outside the Band of Operation*

51. In the *NPRM*, we proposed to require that all emissions from U-NII devices occurring outside of the U-NII bands be attenuated by at least 50 dB or to the radiated emission limits set forth in Section 15.209,⁸⁵ whichever is the lesser attenuation. In addition, we proposed that any emissions occurring in the restricted bands⁸⁶ comply with the radiated emission limits set forth in Section 15.209. We also proposed to amend Section 15.205 to delete 5.15 - 5.25 GHz as a restricted band. Further, we proposed to require that any unwanted emissions comply with the general field strength limits set forth in Section 15.209. Finally, for any U-NII devices that use an AC power line, we proposed to require such devices to comply also with the conducted limits set forth in Section 15.207.⁸⁷

52. *Comments.* Only a few parties commented on the emission limits proposed in the *NPRM*. Several commenters supported the proposal.⁸⁸ For example, Mulcay agrees with the proposal to limit emissions pursuant to Section 15.209. However, other commenters argue that the Commission should permit industry to develop limits on emissions that fall outside the bands of operation.⁸⁹ WINForum supports reliance on emission limits and measurement methods that would be developed by industry and argues that the rules regarding unwanted emissions should be stated in terms of burst average power and should be independent of the power of the fundamental emission.⁹⁰

53. *Decision.* Limits on emission levels outside the bands of operation and frequency stability requirements are necessary to protect adjacent spectrum occupants and sensitive operations that may operate on harmonic frequencies. However, in view of the higher and different power limits we are adopting for U-NII devices in each of these bands, we are making appropriate adjustments to the limits we proposed in the *NPRM* on the permissible emission levels outside the band. Specifically, we will require U-NII devices

⁸⁴ See 47 CFR § 15.203.

⁸⁵ See 47 CFR § 15.209.

⁸⁶ See 47 CFR § 15.205.

⁸⁷ See 47 CFR § 15.207.

⁸⁸ See Mulcay Reply at 7 and Solectek Reply at 16.

⁸⁹ See Motorola Comments at iv.

⁹⁰ See WINForum Comments at 29.

operating in the upper band to attenuate emissions below the maximum power spectral density by a factor of at least 40 dB for frequencies from the band edge to 10 megahertz from the band edge and by a factor of at least 50 dB for frequencies greater than 10 megahertz from the band edge. For the other two bands which have lower maximum power limits we will take this limit as an absolute limit. This will provide the same level of interference protection outside all three bands. Accordingly, the attenuation of peak levels of emissions outside of the frequency bands of operation below the maximum peak power spectral density contained within the bands of operation must be in accordance with the following limits:

- i) For transmitters operating in the band 5.15-5.25 GHz: all emissions within the frequency range 5.14-5.15 GHz and 5.35-5.36 GHz must be attenuated by a factor of at least 27 dB; within the frequency range outside these bands by a factor of at least 37 dB.
- ii) For transmitters operating in the 5.25-5.35 GHz band: all emissions within the frequency range from the band edge to 10 MHz above or below the band edge must be attenuated by a factor of at least 34 dB; for frequencies 10 MHz or greater above or below the band edge by a factor of at least 44 dB.
- iii) For transmitters operating in the 5.725-5.825 GHz band: all emissions within the frequency range from the band edge to 10 MHz above or below the band edge must be attenuated by a factor of at least 40 dB; for frequencies 10 MHz or greater above or below the band edge by a factor of at least 50 dB.

As already specified in the rules, the measurements of such emissions shall be performed using a minimum resolution bandwidth of 1 MHz.⁹¹ Regardless of the attenuation levels shown above, we will not require emissions outside the frequency range of operation to be attenuated below the general radiated emission limits in Section 15.209 of our rules.⁹² Further, we will not specify these emission limits as a maximum power spectral density of the operating band, as requested by WINForum, because such a limit would have to be adjusted with changes in antenna gain in order to maintain a consistent interference potential. The emission limits being adopted are based on the peak power spectral density within the band of operation, and the power spectral density is varied to reflect changes in the gain of the antenna. We recognize that changes to the gain of the antenna at harmonic frequencies may not directly correlate with changes to the antenna gain at the fundamental frequency. However, we believe that the limits being adopted for spurious emissions are sufficient to reduce the probability of harmful interference. Further, the provisions in Section 15.205 of

⁹¹ See 47 CFR § 15.35.

⁹² See 47 CFR § 15.209.

our rules will ensure that harmful interference does not result to critical safety services regardless of antenna gain.⁹³

54. Further, we will adopt our proposal to remove the 5.15-5.25 GHz band from the restricted bands listed at Section 15.205 of the rules.⁹⁴ We note that U-NII devices will have to comply with the provisions of Section 15.205 in order to protect sensitive operations. We also note that the 4.5-5.15 GHz and 5.35-5.46 GHz bands remain restricted; therefore, U-NII devices operating close to the band edges at 5.15 GHz or 5.35 GHz will be required to sharply attenuate their signal at the band edge or avoid using the spectrum close to the band edge. We do not believe that this requirement will significantly affect U-NII operations overall. In any event, this requirement is needed to protect sensitive and safety-of-life operations in adjacent bands. Additionally, we adopt our proposal to require that emissions comply with the general field strength limits set forth in Section 15.209. Finally, any U-NII devices that use an AC power line must comply with the conducted limits set forth in Section 15.207.⁹⁵

4. *Channeling Plan & Modulation Efficiency*

55. In the *NPRM*, we did not propose to adopt limits on channelization or modulation efficiency, but did request comment on whether we should specify a channeling plan or a minimum modulation efficiency requirement for U-NII devices to ensure efficient use of the spectrum. We specifically requested comments on whether a 20 or 25 MHz channeling plan and/or a 1 bit/second/Hz ("bps/Hz") modulation efficiency should be adopted and whether these regulations would be beneficial in facilitating unlicensed broadband high data rate use of these bands.

56. *Comments.* Commenting parties disagree as to whether the Commission should adopt a mandatory channelization plan or minimum bandwidth requirement for unlicensed U-NII devices. Those supporting a channelization plan and/or minimum bandwidth requirement argue that the 5 GHz unlicensed bands should be dedicated for wideband systems. These parties contend that other unlicensed bands such as the U-PCS spectrum are already available for narrower bandwidth applications.⁹⁶ They claim that some channel limitations are needed. They contend that wideband devices with high signaling speed requirements suffer disproportionately from harmful interference caused by narrow bandwidth devices with low signaling speed requirements, and that complex rules would be required to correct this imbalance. WINForum, Lucent, and Nortel support a minimum

⁹³ See 47 CFR § 15.205.

⁹⁴ See 47 CFR § 15.205.

⁹⁵ See 47 CFR § 15.207.

⁹⁶ See Lucent Comments at 3 and WINForum Comments at 25.